How Much and How Quick? Pass through of Commodity and Input Cost Changes to Retail Food Prices

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Following the food, energy, and overall commodity price surge from mid 2007 to mid 2008, both domestic and international retail food prices rose at an accelerated rate for most of 2008. These changes sparked a renewed interest in both food policy and food industry arenas in estimates of the magnitude of the effect of commodity price changes on retail food prices. The subsequent drop in commodity prices during the fourth quarter of 2008 and beginning of 2009 led to the same set of questions in the opposite direction. What impact do volatile swings in commodity prices have on retail food prices? This paper uses Bureau of Labor Statistics (BLS) price index data across various stages of food production along with data on energy and wage costs to estimate: how much of the change in commodity costs is generally passed through to retail prices; how the pass-through rate varies by food type; and just as important, the time lag between commodity price changes and retail price changes across a number of food groups.

A number of factors combined to lead to the run-up in commodity prices in 2007 and 2008. Trostle (2008) divides these factors into supply and demand effects and shows that tight market conditions were the impetus for the sharp increase in food commodity prices. More rapid expansion in demand and slower growth in production began in the 1990s and contributed to declining global demand for reserve stocks of grains beginning in the early 2000s. Then, rising oil prices and evolving biofuel policies provided incentives to expand biofuel production in some countries. In addition the general decline in the value of the dollar over the past decade and international accumulation of foreign exchange reserves in the form of U.S. dollars enabled some countries to increase food commodity imports, even as world prices (in dollar terms) reached record highs. On the supply side, largely due to rising energy prices, production costs for most of the world's farmers increased, and adverse weather conditions in a number of countries in 2006 and 2007 reduced global production of grains and oilseeds. Together, these factors resulted in declining global stock-to-use ratios for many food commodities by the end of 2007. Importers faced declining market supplies, and many countries experienced politically sensitive increases in domestic food prices, leading some to contract aggressively for future imports, even at world record prices. Finally, in late 2007 and early 2008, various exporters of food commodities imposed restrictions on exports in an attempt to moderate domestic food price inflation. These actions, combined with the already tight market conditions, set the stage for the rapid increases in food prices that occurred during most of 2008.

Previous literature on the issue of price pass through shows that results are somewhat sensitive to the data and methods used to estimate the relationship. For example Kim and Cotterill (2008) estimate demand in the U.S. processed cheese market to determine pass-through rates of cost changes under different behavioral regimes and find that, under collusion, the pass-through rates for all brands fall between 21 and 31%, while, under Bertrand-Nash price competition, the range of pass-through rates are between 73 and 103%. Rojas, Andino, and Purcell (2008) focus on retail response to wholesale price changes and use scanner-based quantity-weighted retail prices to suggest that retailers' response to changes in wholesale beef prices is significantly larger and possibly quicker than is shown by

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other measures of retail prices. The *timing* of pass through in the food industry also varies—from just over one month's time to over a year's time to see commodity price changes reflected in retail prices.

Some recent research has begun to address the connection between price changes at earlier stages of production and retail price inflation measures. Hobijn (2008) uses an input-output model to estimate the impact of the grain and oil commodity price increases from 2006 to 2008 on the Personal Consumption Expenditure (PCE) Inflation measure (published by the Bureau of Economic Analysis) and finds, not surprisingly, that increases in these two commodity categories affect personal consumption categories only in related areas (food, tobacco, and gardening supplies for crop prices and fuel, energy and transportation for oil prices). Focusing on the impact on the food portion of the PCE, Hobijn finds about 47% of the increase in retail food prices over the past few years can be attributed to increases in crop prices, while about 19% can be attributed to the increase in oil and gas prices.

Data and Model Description

In order to investigate the magnitude and time lag in the pass through of higher commodity and wholesale costs to retail food prices, I use BLS data from the Consumer Price Index (CPI) for retail food price change, data from the BLS Producer Price Index (PPI) for commodity, farm, and wholesale price change, and grocery store wage data from the BLS Current Employment Statistics survey to measure change in the average hourly wages of grocery store employees for the years 1972–2008. Monthly CPI and PPI values were used to calculate monthly percentage changes in the price of a given food category, and two years' worth of lagged variables were created for all of the explanatory variables to allow for a given input cost price change to affect retail prices for up to two years after an initial price change.

Given the interest in rising food commodity costs over the past two years, my main focus here is on the impact of corn, soybean, and wheat price changes on retail food prices. This analysis assumes that the major impact of changing commodity prices on retail food prices works through the impact of commodity price changes on prices for farm and/or wholesale food prices.

One of the most common uses of both soybeans and corn in the food supply chain is as animal feed used to produce meat from cattle, hogs, and poultry as well as eggs and milk in the poultry and dairy industry, respectively. Energy costs also can play a role in the overall cost structure of the livestock and poultry industry, so I include monthly price changes for corn, soybean, and crude oil over a two-year lagged time period as explanatory variables in a set of regressions on the farm price of the livestock and poultry products listed above. For estimating the impact of changes in wheat prices, I use monthly price changes for wheat and crude oil as explanatory variables to explain changes in wheat flour prices.

A second set of regressions is then used to connect these farm-level and wholesale prices to retail food prices in related categories. In addition to the food price changes at earlier stages of production, I also include price change data on wholesale gasoline and grocery store wages as proxies for energy and labor input costs for the retailer, as these are two of the largest, nonfood costs associated with operating a retail food store.

Since the regression analyses that I use involve time series data for monthly price changes, it is unlikely that the OLS assumption of uncorrelated error terms across the observations will hold. In this case the concern is that the error terms in the given PPI or CPI regression are correlated with error terms from previous time periods in some systematic way. An examination of the price change data shows varying degrees of autocorrelation that would lead to standard error estimates that are biased downward and lead to some truly statistically insignificant parameter estimates appearing to be statistically significant. In order to adjust for this problem, an autoregressive (AR) process is used in the analysis to account for influential lag terms in the CPI and/or PPI data, with the analysis allowing up to twenty-four months of previous data to be used to adjust the error term for a given regression. Therefore, the overall structure of the error term includes both a random portion and some AR terms, with the number of AR terms a function of the level of autocorrelation in a given price series.[1]

Results for Commodity Effects on Wholesale Prices

Beginning with the possibility of a maximum of 24 lags included for each group of potential

[1] Additional details regarding the nature of the autocorrelation in this analysis is available from the author on request.

Table 1. Summary of Pass-through Rates and Timing for Commodity Inputs to Farm and Wholesale Prices

	Corn		Soybeans		Crude Oil	
Dependent Variable	Pass-Through Rate (percent)	Time to Pass Through (months)	Pass-Through Rate (percent)	Time to Pass Through (months)	Pass-Through Rate (percent)	Time to Pass Through (months)
Cattle	8	2 to 9	6	4 to 9	10	2
Hogs	15	3	Negative	4 to 6	5 to 10	9
Poultry	16	4	6	2 to 4	3 to 4	9
Eggs	27	6	Negative	3 to 5	3 to 5	2 to 4
Milk	4	2 to 4	5	6	Negative	4 to 6

	Wheat		Crude Oil	
	Pass-Through Rate (percent)	Time to Pass Through (months)	Pass-Through Rate (percent)	Time to Pass Through (months)
Wheat Flour	41	1 to 2	3	4

explanatory variables in each regression, inspection of the significance of each lag in the initial regressions along with a check of significance as other lagged terms were dropped from the regression was used to determine the final set of lagged explanatory variables included in a given regression.[2]

Looking first at the impact of changes in corn and soybean prices on cattle prices, I find that changes in corn prices take two to nine months to impact the price of cattle, and price changes are passed through at about an 8% rate, meaning that a 10% change in corn prices would be associated with an 0.8% increase in cattle prices. Interestingly, some later lags of corn price change show a significant negative relationship with cattle prices, implying that the dynamics between commodity prices and cattle prices is not always positive; in some cases higher commodity prices could lead to lower cattle prices as, perhaps, feeding duration is limited and cattle are brought to market more quickly and at lower weights. Soybean prices also have a statistically significant impact on cattle prices with a pass-through rate of about 6%. Here, too, the dynamics are complex, with some lags having a short-term negative impact on prices. It should be noted that these corn and soybean estimates come from an analysis that controls for changes in energy prices; crude oil price changes also have a statistically significant effect on cattle prices, with effects showing up as soon as two months and passing through at as much as 10% to cattle prices.

What impact does the cyclical nature of cattle prices have on the current price change? Controlling for autocorrelation in the error terms using a flexible AR process shows a three- to four-month cyclical pattern in cattle prices, even after accounting for the changes in commodity prices.

Turning now to hog prices, a similar analysis shows corn price changes passing through to hog prices at about a 15% rate, while soybean price increases seem to have a net *negative* impact on hog prices—again possibly based on short-term changes in feeding practices in response to higher prices dominating the conventional long-run expected effect. Here, too, higher energy prices are accounted for as higher crude oil prices increase hog prices in about nine to eleven months at a rate of 5–10%. Similarly, poultry prices respond to changes in corn prices in about four months and at a rate of 16%, while soybean prices impact poultry prices in two to four months' time and pass through at about a 6% average rate (table 1).

Egg prices, at all levels of the supply chain, seem to be more volatile than other livestock and poultry prices (table 2) and response to changes in underlying input costs plays a role in this added volatility, with corn price changes passing through to wholesale egg prices in about six months at a 27% rate. Soybean prices seem to have the biggest impact on wholesale egg prices about a year after a given soybean

[2] A complete list of autoregressive terms and a comparison of results with and without this correction are available from the author on request.

Table 2. Egg Price Volatility across Time at Three Stages of Production

Year	Farm-Level Price	Percent Change	Wholesale Price	Percent Change	Retail Price	Percent Change
2002	$0.61	0.0	$0.67	0.0	$1.03	11.0
2003	$0.75	23.0	$0.88	31.3	$1.24	20.6
2004	$0.70	−6.7	$0.82	−6.8	$1.34	7.6
2005	$0.54	−22.9	$0.66	−19.5	$1.22	−9.1
2006	$0.57	5.6	$0.72	9.1	$1.31	7.2
2007	$0.93	63.2	$1.14	58.3	$1.68	28.3
2008	$1.07	15.1	$1.28	12.3	$1.99	18.7

price increase, but the relationship is actually negative in this case, which could be a function of the interaction of soybean prices and the joint egg and poultry production decisions over time. Crude oil prices have a small short-term positive impact on egg prices at about a net 3% pass-through rate but turns equally negative one year after the crude oil price increase.

Farm-level milk prices respond to higher corn prices in two to four months at about a 4% pass-through rate, while soybean prices pass through at a 5% rate in six months' time. Crude oil prices have a small but statistically significant *negative* effect on milk prices once soybean and corn price changes are taken into account.

Although wheat prices surged over a somewhat different timeframe and for somewhat different reasons than soybeans and corn, it is instructive to include an example of pass through of wheat price changes in this analysis. In this case, I look at wholesale wheat flour price changes as a function of wheat and crude oil (as a proxy for energy and processing costs) price changes. Changes in wheat prices pass through to wheat flour prices at a 41% rate initially, while additional statistically significant effects exist for a full year after a given increase. Higher energy prices also impact wheat flour prices in about four months' time at a 3% pass-through rate.

Results for Commodity and Wholesale Effects on Retail Prices

Given the results from the previous section, I now estimate the magnitude and timing of livestock, poultry, and wholesale wheat flour price change on retail food prices and then extrapolate the impact of commodity price changes as a fraction of the observed wholesale price impact. For the retail price analysis, in addition to the wholesale and other PPI food prices included, I also use wholesale gasoline and grocery store wage data as proxies for two of the other major cost drivers of retail food prices—labor and energy costs. Retail beef prices respond to higher cattle prices at an initial 18% pass-through rate and increase at an additional 6% pass-through rate two months after a given cattle price increase (table 3). Taking the corn and soybean impacts on cattle prices and applying that to the retail beef price through this pass-through estimate implies that in three to eleven months' time corn prices pass through to retail beef prices at a 1.4% pass-through rate (8% of the 18%) and add an additional half percent effect in the following month. As a point of comparison, beef prices increased 4.5% in 2008 at a time when corn prices increased at about a 60% annual rate implying a 5% increase in cattle prices and a 0.9% increase in beef prices due to the increase in corn prices. This implies that higher corn prices were responsible for about 19% of the 2008 increase in beef prices. Higher crude oil prices also increase cattle prices and using the same methodology, the doubling of crude oil from the summer of 2007 to the summer of 2008 would increase beef prices by 1.8% (10% of 18) or 36% of the increase in beef prices.

Retail pork prices are much less influenced by changes in hog prices as higher hog prices pass through to retail pork prices at just a 4% rate after one month and an additional 2% in each of the next two months. It is interesting to note that grocery store wages are rather strongly positively correlated with retail pork prices, perhaps suggesting that pork pricing is more a function of the retail market conditions than are retail beef prices, but additional research would be needed to investigate this relationship. The weaker relationship between hog prices and retail pork prices

Table 3. Summary of Pass-through Rates and Timing for Farm and Wholesale Prices to Retail Prices

	Farm-Level Price		Energy		Grocery Store Wages	
Dependent Variable (Retail Prices)	Pass-Through Rate (percent)	Time to Pass Through (months)	Pass-Through Rate (percent)	Time to Pass Through (months)	Pass-Through Rate (percent)	Time to Pass Through (months)
Beef	6 to 18	1 to 2	Negative	3	Not Stat. Significant	—
Pork	2 to 4	1 to 3	2	2	5 to 10	8 to 21
Poultry	6 to 8	1 to 2	3	2	Negative	7
Eggs	5 to 8	3 to 5	5	6 to 9	Negative	4 to 17
Milk	5 to 18	1 to 5	2	2 to 3	Not Stat. Significant	—
White Bread	2 to 6	1 to 6	2	1 to 4	8 to 10	17 to 20
Oranges	11	1 to 2	Not Stat. Significant	—	10 to 15	2 to 13
Lettuce	16	1 to 2	Not Stat. Significant	—	Not Stat. Significant	—

may explain why retail pork prices increased at a significantly lower rate than beef prices in face of higher commodity (and feed) prices in 2008.

Retail poultry prices have a much more persistent relationship to farm-level poultry prices than what is observed in retail pork, as pass through is positive and statistically significant for four of the first five months after a given price change and the pass through is 8% after one month and 6% after two months. This implies that in five to ten months' time, higher corn prices pass through to retail poultry prices at a 1.3% pass-through (16% of 8%) rate and that higher soybean prices pass through to retail poultry prices at a 0.5% pass-through (6% of 8%) rate. Again, as a point of comparison, poultry prices increased 5% in 2008, at a time when corn prices increased at about a 60% annual rate, implying a 9.6% increase in farm-level poultry prices and a 0.8% increase in retail poultry prices due to the increase in corn prices. This implies that higher corn prices were responsible for about 15% of the 2008 increase in retail poultry prices. Higher soybean prices also increase farm-level poultry prices, and using the same methodology, the roughly 80% increase in soybean prices from the summer of 2007 to the summer of 2008 would increase retail poultry prices by 0.4% or about 8% of the increase in retail poultry prices.

Turning to retail egg prices, I find a strong correlation between retail and farm-level egg prices with pass through reaching the retail level three to five months after the farm-level price change. The rate of pass through is 8% for the three-months-ago change with an additional 7% and 5% pass-through response at the four and five months-ago marks, respectively. This implies that the same 60% increase in corn prices referred to above would cause a 1.3% increase in egg prices or about 9% of the 2008 change in retail egg prices.

Changes in retail milk prices garner a lot of attention, as the price of a gallon of milk is a very visible price point in retail food markets. The rapid rise in retail gasoline prices in 2007 and 2008 corresponded with a similar increase in retail milk prices, so both the food commodity and energy commodity impact on milk is of special interest. Not surprisingly, retail milk price changes are strongly correlated with the change in farm-level milk prices, with the impact of farm-level changes passing through to retail in 1 to 5 months' time. The one-month price change passes through at an 18% rate, while the two-months-ago change passes through at a 16% rate, and statistically significant effects are felt for up to a year after the farm-level price change. Using this 18% pass-through estimate along with the corn and soybean pass-through rates to farm-milk prices implies that the large increases in corn and soybean prices from mid 2007 to mid 2008 would lead to a 1.2% increase in retail milk prices or about 20% of the 5.8% change in retail whole milk prices in 2008.

Perhaps the clearest case of the impact of commodity price increases on retail food prices is the example of retail white bread prices. Wholesale wheat flour prices take one to six months to retail bread prices, with the

pass-through rate ranging from 2.2 to 5.5% and statistically significant for five of the first six months. Retail white bread prices increased 14.1% in 2008, and 2.2 percentage points of this change can be attributed directly to increases in wheat prices, while crude oil price increases account for less than 0.2 percentage points of this increase. Together, wheat and crude oil increases account for about 17% of the retail price increase.

As opposed to the multistage analysis above, two examples focusing on the direct impact of changes in farm-level produce prices on retail fruit and vegetable prices round out the items analyzed here. These serve as a contrast to those items presented above that are impacted by food commodities such as corn or soybeans that are publicly traded commodities and may have additional, nonfood market, factors influencing their price. Energy and labor costs are included as control variables in these examples as above, and I present oranges and lettuce as examples of the nature of results for fruits and vegetables (table 3). Farm-price changes for citrus fruit pass through to retail orange prices at an 11% rate, and farm-level lettuce prices pass through to retail lettuce prices at a 16% rate, both within the first two months after the farm-level price change—not surprising for fresh, perishable products.

Implications and Future Research

Despite the sharp decline in commodity prices due to the recession of 2008–2009, the long-term factors that led to accelerated increases in food and energy commodity prices in 2007 and 2008 may soon return, and the impact of these commodity price changes on retail food prices will again be a topic of great interest. Using thirty-five years of U.S. price data, this article shows that food and energy commodity price changes take two to nine months to pass through to farm and wholesale prices, and these price changes pass through at a rates ranging between 2% and 41%, depending on the product and time period in question. In the second part of this analysis, I find that farm and wholesale prices take one to six months to pass through to retail prices and pass through at a rate of 2% to 18%. Extrapolating from these two ranges implies that commodity price changes take four to twenty-seven months to pass through to retail prices and are passed through at rates ranging from less than 0.5% to nearly 7%.

Two cautionary caveats should be considered when assessing the results presented here: (1) Using many years of data when commodity and retail prices were relatively stable may cause these results to understate the overall responsiveness of retail prices to changes in costs when costs change faster than the norm for an extended period of time. A fruitful extension to this work would focus on specific time periods and compare pass-through rates at different percent change levels. It may be the case that pass through becomes larger (and/or faster) at certain higher than normal price change levels, such as was observed from 2006–8, and, in fact, preliminary analysis of recent years of data alone does show some higher pass-through rates; (2) Although I have included eight different food categories in this analysis—more than most previous pass-through studies—analysis of additional food categories may bring added insight to the pass-through question. Ultimately, the unique nature of each food category will impact both the magnitude and timing of pass through, but the results here confirm the notion that as a food item undergoes additional levels of processing, its retail price is less influenced by underlying commodity and farm-level price change. Nonetheless, commodity price changes cannot be ignored when analyzing retail food price dynamics, especially at a time of rising commodity volatility.

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